Tape-Calendering Manufacturing Process for Multi-Layer Thin-Film Solid Oxide Fuel Cells

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Objectives

- Develop a manufacturing process, along with an advanced cell configuration that will contribute to significantly lowering cell first-cost, while improving cell robustness, life, reliability, and maintainability.

Key Milestones

- Develop high performance cells and define the manufacturing process.
- Evaluate the unitized cell design concept.
- Demonstrate cell performance based on the unitized cell design.
- Perform preliminary cost analysis of the manufacturing process.

Approach

The overall approach in this program integrates two key elements, to achieve the program objective: (a) the development of a process based on tape calendering for manufacturing multilayer fuel cell components, and (b) an innovative unitized cell design concept. The manufacturing approach is based on tape calendering as a core technology for fabricating thin-electrolyte cells with integral flowfields. Fabricated components contain multifunctional multilayers to enhance cell performance. The cell configuration is based on a unitized cell concept, in which an individual cell is contained within a metallic housing with its own gas channels and manifolds to form a complete cell package. The fabrication process and cell configuration have all the characteristics required for low-cost production of high-performance cell packages that can be easily used for stack building:

- The tape-calendering process is most suitable for cost-effective manufacturing of multilayer cells proposed in this program. The process has several important advantages: scaleability, simplicity, and robustness. In addition, the process is material independent, thus providing fabrication flexibility. Furthermore, the process can be designed for high-volume production and automation using available commercial equipment.
- The unitized cell configuration has the potential to enhance cell robustness, life, reliability, and maintainability. The unitized cell design simplifies cell quality control (QC), sealing, stacking procedures, stack repair/overhaul, and improves cell handling and robustness.

Results

Progress in this program can be summarized in three areas:

- A preliminary manufacturing process, based on tape-calendering process and unitized cell design, has been defined. Preliminary cost analysis of the manufacturing process has been carried out. Improvements and simplification of the unitized cell design have been incorporated into the cost estimate.
- High cell performance based on multilayer cell design, fabricated using tape-calendering process, has been achieved. A porous anode with developed multilayer anode structure has been improved for high fuel utilization that will enable increasing fuel efficiency. For example, after demonstrating steady power

generation for 120 hours at 75% fuel utilization, this new cell achieved stable power at a fuel utilization of 85% (Figure 1). This result is significant in that cells tested previously experienced a dramatic power loss upon pushing fuel utilization beyond 75%. In addition to the anode, cathode microstructure has been engineered for reduced temperature operation. Peak power density of ~0.9 W/cm^2 at 660°C has been demonstrated (Figure 2).

- Power density has been significantly improved for planar solid oxide fuel cells, based on multilayer thin-film unitized cells made by the tape calendering manufacturing process. For instance, the performance at 800°C with 64% H_2 (balance N_2) are (Figure 3):
- 280 mW/cm^2 @ 70% fuel utilization on 1st pass and operating at 0.7 volts
- 300 mW/cm^2 @ 80% fuel utilization on 1st pass and operating at ~0.6 volts.

Conclusions

The program for developing a tape calendering manufacturing process for multi-layer thin-film solid oxide fuel cells was awarded in FY 2000. Significant progress in the multilayer manufacturing process has been achieved. Cells fabricated with the tape-calendering process, combined with unique cell designs have exhibited excellent performance. The improved cell performance and simplified fabrication process will potentially reduce the overall manufacturing cost.

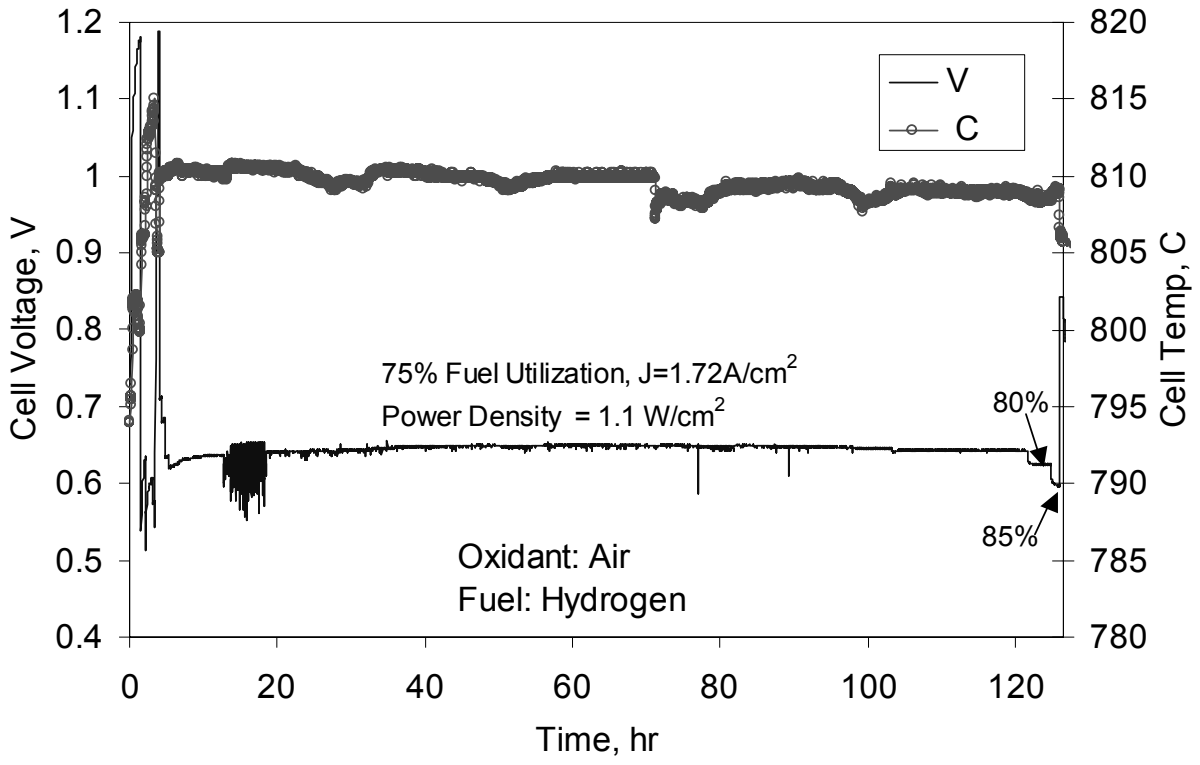

Figure 1: *High fuel utilizations are demonstrated with a multi-layer single cell.*

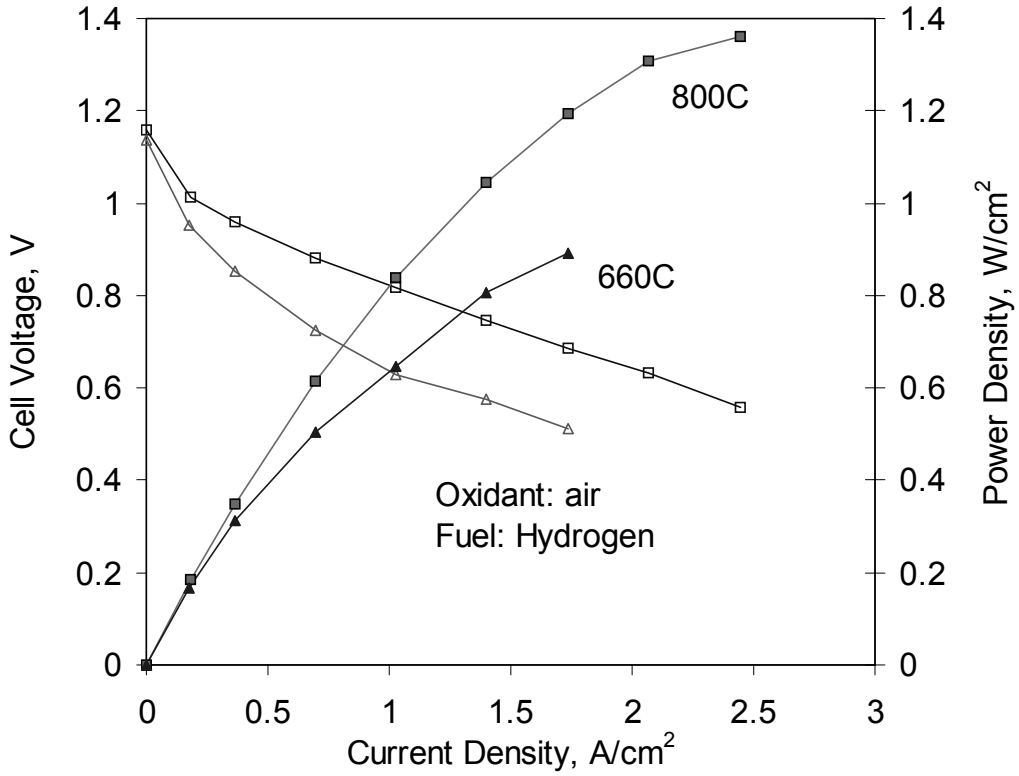

Figure 2: *Single cell performance at reduced temperatures.*

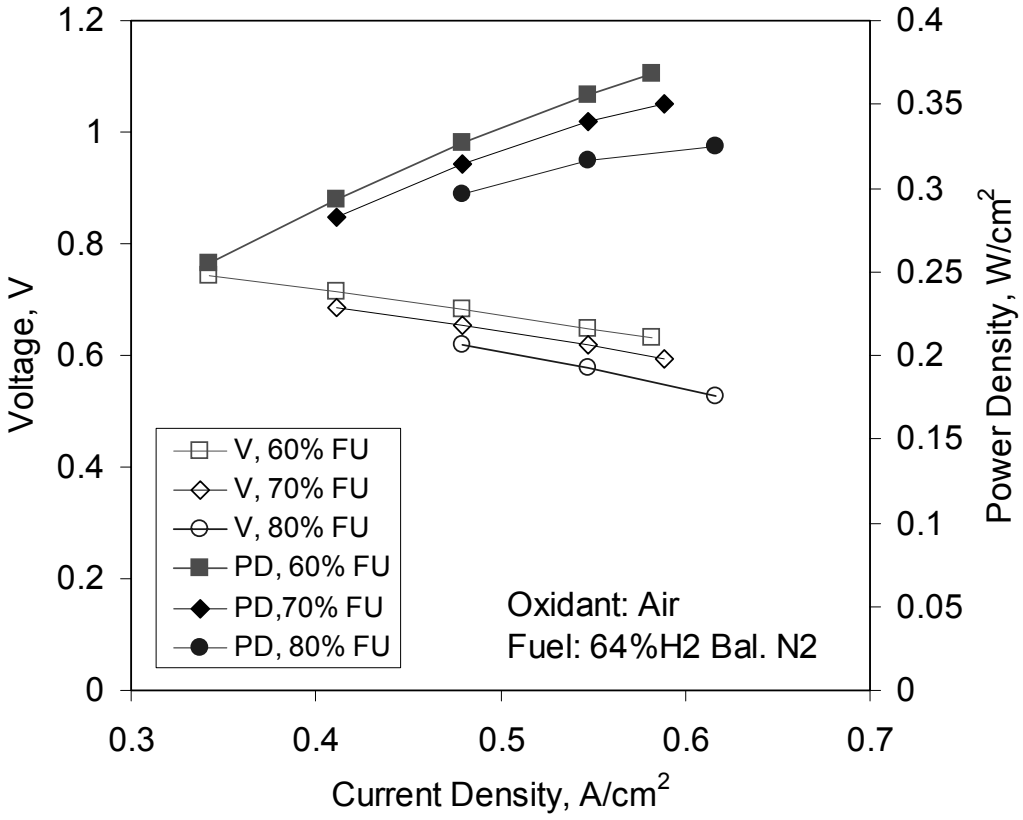

Figure 3: *Performance of unitized cell design.*